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Report of the Joint Canada – USA Review Group on the Stock Assessment of Coastal Pacific Hake/Whiting Stock Off the West Coast of North America February 17-18, 1999

M. Stocker, D. Welch and R. Conser (Editors)
Pacific Scientific Advice Review Committee (PSARC)
Pacific Biological Station
Nanaimo, British Columbia V9R 5K6

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PACIFIC SCIENTIFIC ADVICE REVIEW COMMITTEE

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PACIFIC GROUNDFISH

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INTRODUCTION

The first joint meeting of the Canadian PSARC's Groundfish Subcommittee on Pacific Hake and the USA Pacific Fishery Management Council's STAR Panel for Pacific Whiting was held at the Best Western Pacific Inn, White Rock, British Columbia, Canada during 17-18 February 1999. The list of attendees is given as Appendix 1.

The joint PSARC Subcommittee – PFMC STAR Panel, hereafter referenced as the Review Group, received the primary draft assessment document during the week prior to the Review Group meeting:

Dorn, M.W., M.W. Saunders, C.D. Wilson, M.A. Guttormsen, K. Cooke, R. Kieser, and M.E. Wilkins. 1999. Status of the coastal pacific hake/whiting stock in U.S. and Canada in 1998. 89p.

A supplementary document, "Summary of Stock Status," was distributed at the beginning of the Review Group meeting. D. Welch (Canada) and R. Conser (USA) served as co-chairmen. Following welcome and introduction of attendees, the Review Group heard the following presentations:

Overview of the Assessment	M. Dorn (NMFS -- Seattle)
Results of the 1998 NMFS Shelf Survey	M. Wilkins (NMFS -- Seattle)
Results of the 1998 NMFS Acoustic Survey	C. Wilson (NMFS -- Seattle)
Results of the 1998 Canadian Acoustic Survey	M. Saunders (DFO – Nanaimo)

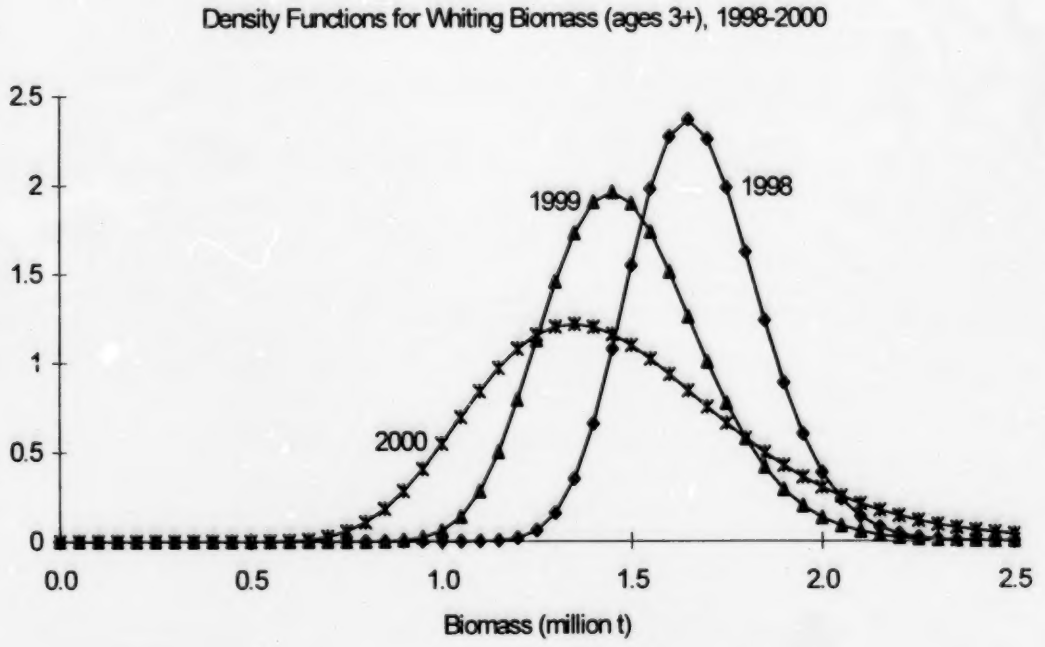
During their presentations and over the course of the 2-day review, the assessment authors provided additional information and data that greatly assisted the Review Group in carrying out its work.

A summary of the draft assessment document (prepared by the authors) is given as Appendix 2.

SUMMARY OF STOCK STATUS

The Group agreed with the Dorn et al. (1999) assessment that the best estimate of 1998 stock abundance is 1.7 million metric tonnes, with uncertainty as indicated from the approximate probability density functions (Figure 31 of Dorn et al.; reproduced below). The Group concurred with the assessment methods used in the analysis, and the approximate density functions for the stock projections in the years 1999 and 2000, also shown in the summary figure below.

- Catches have been fairly stable in recent years. The average catch over the last five years was 310,000 t. The 1998 catch was 319,000 t.
- The assessment of the Pacific whiting stock is based on acoustic surveys as the primary measure of stock abundance. These surveys are thought to provide relatively good estimates of stock biomass, especially in the most recent years.
- While spawning biomass has been declining, it is now thought to be at or near management target levels.
- Harvests are projected to decline modestly over the next few years. The absence of any strong year-classes this decade has resulted in recruitment for the 1990-98 period to be only 65% of the long-term average. Projected recruitment levels for the next two years are below average.



DETAILED COMMENTS FROM THE REVIEW

Surveys

It was generally agreed that the current approach of relying primarily on the results from the NMFS acoustic survey was appropriate for abundance estimation. The NMFS bottom trawl survey and the DFO acoustic survey do not cover the full geographical range of Pacific whiting, and abundance trends derived from them may be biased due to changes in local availability. Further, the bottom trawl survey may not accurately sample the whiting size/age distribution found in the entire water column. The last three NMFS acoustic surveys (1992, 1995, and 1998) have been the most reliable, in the sense that these surveys have unambiguously covered the entire area of the whiting distribution, extending out into regions to the north and the offshore that were clearly beyond the current distribution of whiting.

The Group examined the strong selectivity at age evident in the model results for the NMFS acoustic surveys. This dome-shaped pattern results in lower apparent availability for younger and older age groups. Such a selectivity pattern was thought to be somewhat unusual for an acoustic survey, but may occur due to age-specific differences in density or availability to the sampling net. Further, in order to obtain reasonable results, the authors found it necessary to impose a strong constraint on the initial slope parameter of the selectivity curve. Otherwise peak selectivity would have shifted over to older ages, resulting in an unreasonably large biomass of "unseen" young fish. The Group recommended that possible explanatory factors for the dome-shaped selectivity be further explored prior to the next assessment.

Sensitivity analysis (Figure 21; upper left panel) indicates that both the trend and absolute level of stock biomass in recent years are strongly dependent upon which of the surveys were used to "tune" the assessment model. In particular, incorporation of the NMFS bottom trawl survey (with weighting roughly equal to that of the NMFS acoustic survey) resulted in much larger stock biomass estimates in recent years. As discussed above, there was a consensus amongst the Group, based on general principles, that the NMFS acoustic surveys were the most reliable. However, the Group felt that the key hypotheses used to discount the utility of the bottom trawl survey required more rigorous examination. For example, the hypothesized positive bias in stock trend from bottom trawl surveys due to increasing availability of whiting to both the survey area (more whiting inshore over time) and depth (more whiting near the bottom over time). More specifically, the Group suggested that inshore/offshore location data and the depth data from the NMFS acoustic survey database may be amenable to testing these hypotheses in future assessments.

The possibility of double-counting (or under-counting) whiting because of their movement over the duration of the survey was also discussed. Surveys take about two months to complete, but are generally set in the summer because it appears that the whiting seem to have stopped their active north-south migrations and have reached

their feeding grounds. Any movement at that point appears to be basically inshore/offshore, so it is unlikely that there is significant double-counting (or under-counting) of fish because of their migratory movements.

Biological Assumptions

A significant decline in mean weight-at-age was evident in the data. Anecdotal evidence indicates that this is a rather widespread phenomenon for west coast groundfish, starting around 1990. Stock biomass estimates presented in the whiting assessment account for the change in annual mean weights. However, the effect of a biomass consisting of a larger number of smaller individuals on true spawning potential is not well understood. Further, the spawning biomass appears to have become progressively more heavily dependent on the contribution of 3, 4, and 5 year old females. There is a growing dependence on a few younger age classes. Particularly with the changes to lower weight at age that appear to be occurring, the restriction of spawning to a few age classes makes the population more vulnerable to periods of poor recruitment.

An important assumption in the current model runs is that the maturity ogive is time invariant. This ogive is based on a rather limited number of samples taken during the early 1990's. Anecdotal evidence suggests that the recent large declines in growth have resulted in smaller animals in probably poorer condition. Given the current dependence on younger fish, the assumption of a constant maturity ogive needs to be carefully assessed.

Fisheries Data

The basic fisheries data for Pacific whiting appear to be sound, especially when compared to the fisheries data available for other west coast groundfish assessments. As a research recommendation, the Group suggested evaluating the effect of using a more straightforward catch-at-age matrix without the accumulation of "marginal" age groups. The accumulation rules employed are somewhat arbitrary and further examination may show that such accumulation is unnecessary.

Model Assumptions

The Group agreed that the assumptions used in the model were reasonable and that the paper provided a very clear summary of what was involved in the analysis.

Harvest Projections

The use of the NMFS Tiburon Lab's larval survey indices and recruitment indices from the NMFS bottom trawl survey for the prediction of whiting recruitment (in 1999 and 2000) is a departure from past whiting assessments, in which mean historical recruitment was used for future recruitment. The Group did not discuss at length the merits of the Tiburon larval survey as a predictor of coastwide whiting recruitment, other than noting the limited geographic range of the larval survey. However, it was noted that the incorporation of this larval survey resulted in the prediction of relatively poor

recruitment in 1999 and 2000. The effect of incorporating the bottom trawl survey recruitment indices was negligible.

The current projections are based on mean recruitment plus recruitment indices, inversely weighted by their variances. Depending on which index is used, rather large differences in future recruitment are forecast. All of these components have high associated variance in forecasting recruitment. Caution in the use of the projections for forecasting future biomass levels may be prudent.

Stock Status

The Group agreed with the assessment that the best estimate of 1998 stock abundance is 1.7 million metric tonnes, with uncertainty as indicated from the approximate probability density functions (Figure 31 of Dorn et al. – also shown above). The Group concurred with the assessment methods used in the analysis, and the approximate density functions for the stock projections in the years 1999 and 2000, also shown in the summary figure above.

Other summary attributes of stock status are given in the Summary of Stock Status section, above, and also in Appendix 2. Overall, the current stock status appears to be at or near the desired level given the reference harvest rates that have been used for whiting management (Table 14 Appendix 3 and Appendix Table 2 of Dorn et al.) However, all such conclusions regarding stock status should be taken with the several caveats foremost in mind. Unusual juvenile and adult distribution patterns have been seen in the Pacific whiting population in recent years. Frequent reports of large numbers of juveniles from Oregon to British Columbia suggest that spawning and juvenile settlement has spread northwards. It is not yet clear whether these changes will be a benefit or a detriment to stock productivity and stability. More importantly, whiting eggs and larvae may be subject to unfavorable transport, and juveniles to increased predation and to increased vulnerability to fishing mortality.

Virgin Biomass Estimation

The Group discussed the reliability of virgin biomass (B_0) estimates only briefly. It was noted that ratios of current biomass to virgin biomass (e.g. as in Table 15) should be used with caution since the errors associated with B_0 estimates (both bias and variance) may be large and are difficult to quantify.

Harvest Recommendations

There have been significant changes since 1990 in the growth, distribution of the overall stock, and a change in spawning biology, with spawning occurring at least as far north as northern Oregon and probably off the west coast of Vancouver Island. Although the mechanisms for these changes are poorly understood, they nevertheless suggest that managers may want to be precautionary when selecting quota levels for 1999, particularly if a risk-averse management strategy is desired.

It was noted in Table 14 (included as Appendix 3) that the first row represented an inappropriate fishing mortality rate ($F_{35\%}$) in that it exceeds F_{MSY}. Consequently, the link needed to be clearly drawn for managers between Table 14 and Appendix Table 2 when making decisions on appropriate harvest ranges. The authors indicated that they would re-write the section of Dorn et al. on $F_{40\%}$ to make it clear that this level was a legitimate proxy for F_{MSY}, based on the meta-analysis detailed in the paper. It was the consensus of the Group that this was a reasonable approach. Catches resulting from the $F_{40\%}$ harvest policy would therefore not be "safely" below the F_{MSY} policy, but at or near the maximum level.

Management Goals and Objectives

Several management strategies based on varying fishing rates with biomass were presented in the document and provided a useful description of alternative control policies. There are some potential problems with the hybrid F policy and the consensus of the Group was that additional work should be done on quantitatively evaluating alternative control laws that might provide improvements over the hybrid policy.

APPENDIX 1. LIST OF ATTENDEES

DFO/PSARC:
B. Ackerman
J. Fargo
M. Joyce
S. McFarlane
M. Saunders (author)
M. Stocker (PSARC Chair)
R. Stanley (reviewer)
D. Welch (Review Group Co-Chair & Chair, Groundfish PSARC Committee)
N. Wiliscroft (DFO International)

NMFS/PFMC:
W. Clark (IPHC; reviewer)
R. Conser (Review Group Co-Chair & PFMC SSC Representative)
M. Dorn (author)
J. Hastie (PFMC GMT Representative)
D. Myer (PFMC GAP Representative)
C. Schmitt (Stock Assessment Coordinator)
M. Wilkins (author)
C. Wilson (author)

TRIBES
S. Joner (Makah Tribe)

INDUSTRY/PUBLIC:
V. Wespestad (Pacific Whiting Cooperative)
E. Zyblut (DSTA)
D. March (CGRCS)
B. Turris (CGRCS)
K. Kurita (The Minato Shimbum)
S. Anthonson (Fisherman)
M. Antonson (Hake Processor)
A. Laing (Hake Consortium)
J. Radil (Association of Hake Fishermen)
A. Radil (Fisherman)
J. Salisbury (Supreme Alaska Seafood)
H. McBride (Fisherman)
J. Roach (Fisherman)

APPENDIX 2. WORKING PAPER SUMMARY OF STOCK STATUS

G99-1 **Status of the Coastal Pacific Hake/Whiting Stock in U.S. and Canada in 1998.**

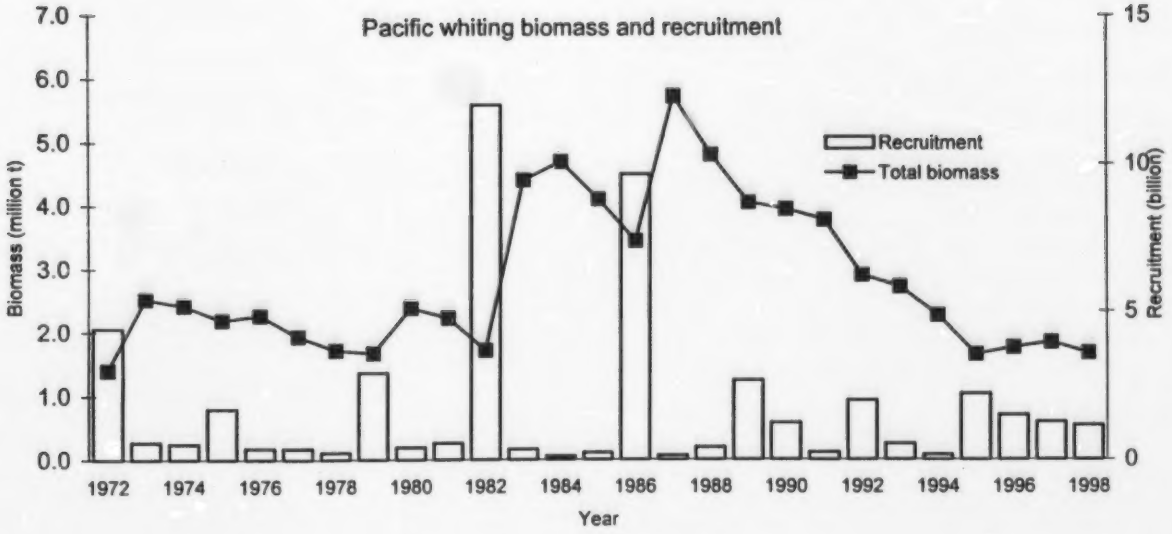
M.W. Dorn, M.W. Saunders, C.D. Wilson, M.A. Guttormsen, K. Cooke, R. Kieser and M.E. Wilkins **Accepted subject to revisions.**

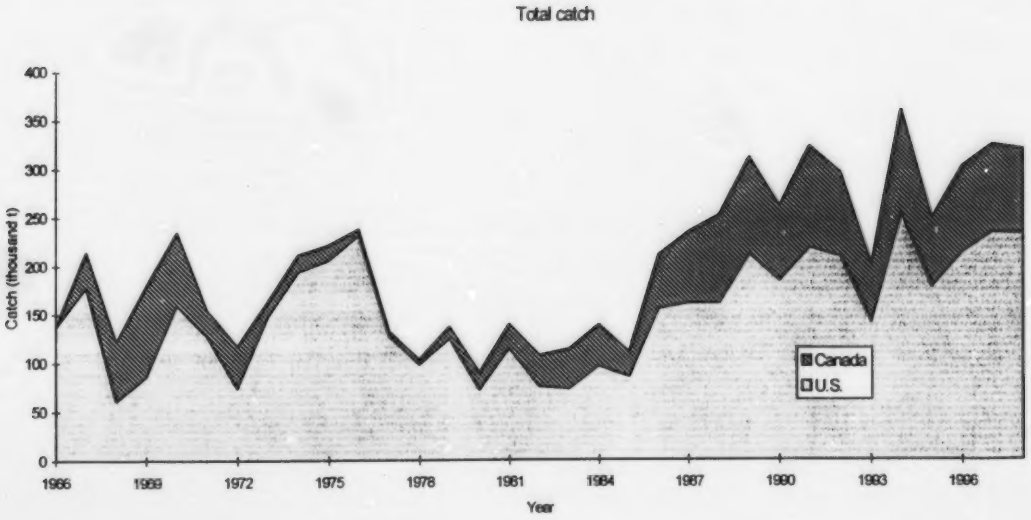
The coastal population of Pacific whiting (*Merluccius productus*, also called Pacific hake) was assessed using an age-structured assessment model. The U.S. and Canadian fisheries were treated as distinct fisheries in which selectivity changed over time. Catch and age data from these fisheries were supplemented with survey data from the Alaska Fisheries Science Center (AFSC) triennial acoustic survey, the AFSC triennial shelf trawl survey, the Department of Fisheries and Oceans acoustic survey, and the Southwest Fisheries Science Center midwater trawl recruit survey. New data in this assessment included updated catch at age, recruitment indices from the SWFSC recruit survey, and results from the triennial acoustic and shelf trawl surveys conducted in summer of 1998.

Status of Stock: The whiting stock is at moderate abundance. Stock biomass increased to a historical high of 5.7 million t in 1987 due to exceptionally large 1980 and 1984 year classes, then declined as these year classes passed through the population and were replaced by more moderate year classes. Stock size has been stable over the past four years at 1.7-1.8 million t. The mature female biomass in 1998 is estimated to be 37% of an unfished stock. Although 1998 stock size is near a historical low, it is close to average stock size under current harvest policies. The exploitation rate was below 10% prior to 1993, then increased to 17% during 1994-98. Total U.S. and Canadian catches have exceeded the ABC by an average of 12% since 1993 due to disagreement on the allocation between U.S. and Canadian fisheries.

Pacific whiting (hake) catch and stock status table (catches in thousands of metric tons and biomass in millions of metric tons):

Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
U.S. landings	161	211	184	218	209	141	253	178	213	233	233
Canadian	90	100	77	105	86	59	106	70	88	91	87
Total	251	311	260	322	295	200	359	248	301	324	319
ABC	327	323	245	253	232	178	325	223	265	290	290
Age 3+ stock	4.8	4.1	4.0	3.8	2.9	2.7	2.3	1.7	1.8	1.8	1.7
Female mature	2.4	2.1	2.0	1.9	1.5	1.4	1.2	0.9	0.9	0.9	0.8
Exploitation rate	5%	8%	7%	9%	10%	7%	16%	15%	17%	18%	19%


Pacific whiting biomass and recruitment
Biomass (million t)
Recruitment (billion)
Recruitment
Total biomass
Year
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
15
10
5
0
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998


Total catch
Catch (thousand t)
Year
Canada
U.S.
400
350
300
250
200
150
100
50
0
1966
1969
1972
1975
1978
1981
1984
1987
1990
1993
1996

Data and Assessment: An age-structured assessment model was developed using AD model builder, a modeling environment for developing and fitting multi-parameter non-linear models. Earlier assessments of whiting used the stock synthesis program. Comparison of models showed that nearly identical results could be obtained under the same statistical assumptions. The treatment of fishery and survey data was similar to previous assessments, except that a new approach to modeling changes in fishery selectivity was introduced.

Major Uncertainties: The whiting assessment is highly dependent on survey estimates of abundance. Since 1993, the assessment has relied primarily on an absolute biomass estimate from the AFSC acoustic survey. The acoustic target strength of Pacific whiting, used to scale acoustic data to biomass, is based on a small number of *in situ* observations. The fit to the entire acoustic survey time series is relatively poor. The AFSC shelf trawl survey biomass shows an increasing trend, conflicting with the decreasing trend in the acoustic survey.

Target Fishing Mortality Rates: An evaluation of whiting harvest policy led to the recommendation that the 40-10 option be considered for whiting. The 40-10 option results in similar harvest rates as the hybrid F policy used previously for whiting, and may improve economic performance of the fishery by dampening variability in harvests. An appendix to the assessment described a meta-analysis of hake stock-recruit relationships. Results indicated that the genus Merluccius may be less resilient to fishing than other gadoids. A Bayesian decision analysis produced estimates of FMSY in the F40% to F45% range depending on the degree of risk-aversion.

Projection table (Coastwide yield in thousands of tons, biomass in millions of tons):

	Coastwide yield			3+ Biomass		
Harvest	1999	2000	2001	1999	2000	2001
F35%	405	350	298	1.5	1.4	1.1
F40%	320	297	266	1.5	1.4	1.2
F45%	259	251	234	1.5	1.5	1.3
40-10	301	275	238	1.5	1.5	1.2

Other considerations: Unusual juvenile and adult distribution patterns have been seen in Pacific whiting population in recent years. Frequent reports of large numbers of juveniles from Oregon to British Columbia suggest that spawning and juvenile settlement has spread northwards. It is not yet clear whether these changes will be a benefit or a detriment to stock productivity and stability. From an assessment perspective, the strength of recruiting year classes may be overestimated--although the use of time-varying fishery selectivity in the assessment model should counteract this tendency. More importantly, whiting eggs and larvae may be subject to unfavorable transport, and juveniles to increased predation from cannibalism and to increased vulnerability to fishing mortality.

APPENDIX 3 PROJECTIONS OF WHITING YIELD FOR 1999-2003 UNDER DIFFERENT HARVEST POLICIES[1]

Harvest rate policy	Year	Age 3+ biomass (million t)		Spawning Biomass (million t)		Age-2 Recruits (billion)		Exploitation rate		Total yield (t)	
F35%	1999	1.498	(0.14)	0.732	(0.13)	1.442	(0.82)	27.0%	(0.06)	405,000	(0.13)
	2000	1.368	(0.25)	0.634	(0.20)	0.490	(0.86)	25.6%	(0.09)	350,000	(0.19)
	2001	1.058	(0.32)	0.533	(0.29)	1.678	(1.22)	28.2%	(0.11)	298,000	(0.26)
	2002	1.105	(0.53)	0.514	(0.42)	1.678	(1.22)	26.0%	(0.20)	287,000	(0.38)
	2003	1.246	(0.61)	0.570	(0.54)	1.678	(1.22)	24.6%	(0.17)	307,000	(0.50)
F40%	1999	1.498	(0.14)	0.732	(0.13)	1.442	(0.82)	21.4%	(0.06)	320,000	(0.13)
	2000	1.448	(0.24)	0.675	(0.20)	0.490	(0.86)	20.5%	(0.09)	297,000	(0.18)
	2001	1.175	(0.30)	0.594	(0.27)	1.678	(1.22)	22.7%	(0.10)	266,000	(0.24)
	2002	1.233	(0.49)	0.581	(0.39)	1.678	(1.22)	21.2%	(0.19)	261,000	(0.35)
	2003	1.381	(0.57)	0.639	(0.50)	1.678	(1.22)	20.1%	(0.17)	278,000	(0.46)
F45%	1999	1.498	(0.14)	0.732	(0.13)	1.442	(0.82)	17.3%	(0.05)	259,000	(0.13)
	2000	1.508	(0.24)	0.705	(0.19)	0.490	(0.86)	16.7%	(0.09)	251,000	(0.18)
	2001	1.269	(0.29)	0.642	(0.26)	1.678	(1.22)	18.5%	(0.09)	234,000	(0.24)
	2002	1.342	(0.46)	0.637	(0.36)	1.678	(1.22)	17.4%	(0.17)	234,000	(0.33)
	2003	1.500	(0.54)	0.701	(0.47)	1.678	(1.22)	16.6%	(0.16)	250,000	(0.43)
F40% (40-10)	1999	1.498	(0.14)	0.732	(0.13)	1.442	(0.82)	20.1%	(0.07)	301,000	(0.19)
	2000	1.467	(0.24)	0.684	(0.19)	0.490	(0.86)	18.7%	(0.06)	275,000	(0.26)
	2001	1.211	(0.27)	0.613	(0.25)	1.678	(1.22)	19.6%	(0.12)	238,000	(0.35)
	2002	1.290	(0.45)	0.610	(0.35)	1.678	(1.22)	18.4%	(0.14)	238,000	(0.50)
	2003	1.452	(0.52)	0.676	(0.45)	1.678	(1.22)	18.5%	(0.15)	269,000	(0.61)
Hybrid F Moderate	1999	1.498	(0.14)	0.732	(0.13)	1.442	(0.82)	14.3%	(0.12)	214,000	(0.25)
	2000	1.552	(0.22)	0.727	(0.18)	0.490	(0.86)	13.8%	(0.11)	214,000	(0.32)
	2001	1.342	(0.25)	0.680	(0.22)	1.678	(1.22)	14.4%	(0.17)	193,000	(0.40)
	2002	1.443	(0.41)	0.690	(0.31)	1.678	(1.22)	13.9%	(0.20)	200,000	(0.56)
	2003	1.620	(0.47)	0.763	(0.40)	1.678	(1.22)	14.6%	(0.28)	236,000	(0.72)

[1] These projections use the revised 1998 DFO survey biomass of 289,082 t. Coefficients of variation are in parentheses.